**Mars Landing Site Considerations; Reconciling the Grab Bag and In Situ Scenarios** S.M. Metzger, Desert Research Institute, Quaternary Sciences Center, 7010 Dandini Blvd., Reno NV, 89512, metzger@scs.unr.edu

Plans for the 2001 rover mission to the Martian equatorial region include the examination and collection of nearly 100 rock core and soil samples along a traverse extending over several kilometers. This ambitious effort, and the similar 2003 mission planned to follow it, will provide the opportunity to gather a wide array of specimens with the potential to elucidate the geologic history and environmental setting of early Mars, perhaps with insight into the development of biological processes. Although numerous samples gathered over several square kilometers is a considerable improvement over prior surface examinations, it still represents a highly constrained exposure to the complexity of Martian geology. How then to maximize the scientific return from the 2001 rover mission?

Two fundamental sampling philosophies have emerged; seeking a “grab bag” site which presents an diverse but disordered array of accessible specimens that formed at some distance from their current setting, and an “in situ” site wherein specimens are presented in context to each other, as they had formed, ideally condensed within a short travel range. Each approach has important ramifications which must be considered.

The Mars Pathfinder lander-rover system had limited but impressive mobility. Ares Valles was an excellent landing site choice because circumstantial evidence was convincing that material had been swept into the area by numerous floods draining a huge upland region. The potential for varied rock specimens within a small area matched nicely with the system’s capabilities. Indeed, MPF is a fine definition of the “grab bag” approach. [1] However, while no doubt there are locations where a major flood did succeed in entraining a wide assortment of rock samples throughout the event, it is more likely that any given postage-stamp depositional setting received its sediment from a specific restricted source. Furthermore, most fluid transport processes, with the partial exception of debris flows, induce strong biasing imprints on their products. Clast size and density are readily sorted by minor fluctuations in the medium’s energy. Less indurated materials are effectively destroyed. [2] The surficial material accessible to a rover may represent a single, final flood event phase, despite the rich depositional record that may lie just below that surface and out of reach. [3] Cratering processes are also proposed as a relevant means to deliver a variety of rocks to the surface. While this is often true, there are similar concerns about which rock types will survive such emplacement and the degree to which known sorting processes will influence ejecta distribution. Thus the modest mixture of rocks found in the MPF “yard” should not seem a surprise. [4] Perhaps then the weakness of the grab bag approach is that easy access is provided only to a limited range of material.

The in situ strategy is no walk in the park either. Most proposed sites that seek out long-term records of geologic environments, especially those with a biologic component, are understandably focussed on subaqueous sedimentary units. Although dry lake or marine deposits can provide the areal coverage and minimal surface relief that eases engineering challenges, those very factors may guarantee a site covered by a single depositional event of such breadth that the rover couldn’t possible travel to a more interesting location. None the less, the value of acquiring *in-context* samples is of such importance to a maturing understanding of regional geologic history that it deserves a closer look. [5]

The AGI definition of stratigraphy places much of this discussion in the appropriate perspective; “(a) The science of rock strata. It is concerned not only with the original succession and age relations of rock strata but also with their form, distribution, lithologic composition, fossil content, geophysical and geochemical properties -- indeed, with all characters and attributes of rocks as strata; and their interpretation in terms of environment or mode of origin, and geologic history. All classes of rocks, consolidated or unconsolidated, fall within the general scope of stratigraphy. Some nonstratiform rock bodies are considered because of their association with or close relation to rock strata (ISG, 1976, p. 12). Syn: stratigraphic geology. (b) The arrangement of strata, esp. as to geographic position and chronologic order of sequence. (c) The sum of the characteristics studied in stratigraphy; the part of the geology of an area or district pertaining to the character of its stratified rocks. (d) A term sometimes used to signify the study of historical geology." [6] At some point our study of the Martian geological record *must* mature to the level of seriously including stratigraphic sections. But what can realistically be done with the Athena '01 rover?

Several investigators at this workshop have focussed on the probable sedimentary record to be found in Noachian crater basins at the northern margin of the ancient southern terrains. Whereas the longevity of river bank deposits is endangered by subsequent flood events, crater basins are likely to preserve the materials that accumulate in them. Major floods are certainly capable of delivering considerable detritus to the basins but smaller or more local discharge events can contribute equally valuable material. Indeed, layered playa deposits on the order of a few millimeters thickness may provide the optimal combination of revealing strata condensed into a durable but accessible specimen. [7,8] Such a record is especially relevant to the Athena mission objective of appraising environmental settings because the emplacement mechanisms are all directly the result of surficial processes which reflect land-atmosphere interaction.

Depositional basins can also incorporate the benefits of the "grab bag" approach. If the region is aggrading, the infill will preserve the prior surfaces where impact ejecta reflected the "quarrying" of underlying strata or where a debris flow had strewn its sediment load. In an appropriate basin there is a high probability that *numerous* fruitful depositional events have occurred and now reside *in context* chronologically to each other within the geologic record. [5,8] If accessible, a dozen grab bag sites may be offered vertically (and laterally) instead of one horizontally.

The logistics challenge is to find a site where such strata are accessible. Wrinkle ridges or similar local tectonic activity may produce scarps and cliff faces. However, unless the scarp has a very gentle slope, landing and rover-mobility constraints would rule out that option. Many basins and broad channels can be seen (in Viking and MGS imagery) to be occupied extensively with active aeolian features that hide the strata beneath. But the same wind processes that inhibit exploration elsewhere may be used to advantage for the 2001 mission. Persistent erosive wind action has exposed large sections of apparently horizontal strata in numerous locations. Although some rugged yardangs would pose too great a challenge for landing and rover operations, many deflation areas are more benign [3].

If active-deflation that is scouring into sedimentary material and extends across an area appropriate to the necessary landing ellipse can be identified, several key logistics would be met;

1. Broad, gently sloping landing area
2. Immediately samplable terrain any where within the ellipse (vs. driving off to the desirable collection sites)
3. "Staircase step" exposures of undisturbed, sequentially developed strata
4. Several opportunities for sampling ancient "grab bag" collections, with each emplacement event maintained in proper context to the regional geologic history
5. Good sample gathering conditions due to little, if any modern surficial overburden material
6. Excellent bedrock exposure of fresh surfaces (lacking in surficial dust drapes) for imaging and spectroscopic examinations
7. Potential deflation lag material eroded from earlier layers thus representing another type of "grab bag" (extensive accumulation of such lag could be avoided by using the same thermal inertia, albedo, and radar roughness data that will certify any site's rockiness)
8. Broad, gently sloping landing area for the 2005 sample retrieval mission.

Ultimately, an extensive exposure of sedimentary strata will offer a more diverse record of Mars' geologic history than any single, process-biased grab bag site. Our challenge is to find such a basin that will be a safe place in which to work.

References: [1] Golombek et al, 1997, Sci. v. 278. [2] J.R.L. Allen, 1985, Principles of Physical Sedimentology, London, George Allen and Unwin, 272 p. [3] J.D. Collinson, and D.B. Thompson, 1989, Sedimentary Structures, New York, Chapman and Hall, 207 p. [4] Rover Team, 1997, Sci. v. 278. [5] H.G. Reading, ed., 1986, Sedimentary Environments and Facies, Blackwell Scientific Publications, 615 p. [6] R.L. Bates, and J.A. Jackson, eds., 1995, Glossary of Geology: Alexandria, American Geological Institute, CD-ROM [7] R.A. Davis, 1992, Depositional Systems, Englewood Cliffs, Prentice-Hall, 604 p. [8] G. Einsele, 1992, Sedimentary Basins: new York, Springer-Verlag, 628 p.